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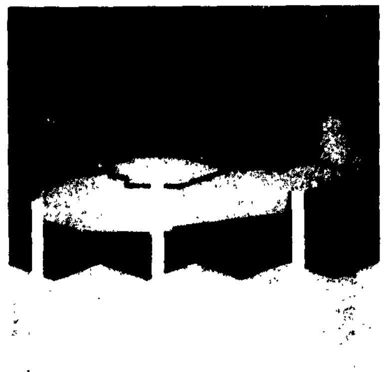

APPLICATION OF THE VERTICAL-FLOAT CONCEPT TO A 1/20 SCALE PBM-5 SEAPLANE

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APPLICATION OF THE VERTICAL-FLOAT CONCEPT TO A 1/20 SCALE PBM-5 SEAPLANE

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Final Report

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ILLUSTRATIONS

FOREWORD

To more fully ensure the success of a proposed full-scale, vertical-float seaplane program, limited testing was conducted on a 1/20 scale PBM-5 seaplane model. The model testing was done during the summer of 1962 at the towing basin facility of Convair's Hydrodynamic Laboratory and in San Diego bay, adjacent to the laboratory.

An analytical study was made to determine the size and position of the floats to be installed on this particular model. Tests were then conducted on both the hull configuration and the stable, vertical-float version, and comparative data was recorded for pitching, rolling, and heaving motions induced by wave action.

The test results indicated that the vertical-float installation impressively reduces pitching, rolling, and heaving motions of a seaplane over the range of wave conditions for which it is designed.

INTRODUCTION

In future ASW activities utilizing a seaplane, extended waterborne operation will be necessary. During these waterborne periods, crew members will be subject to the motions induced by the existing sea conditions. For effective operations, these motions must be kept within the physical tolerances of the human crew as well as the structural limits of the vehicle itself. One method of controlling these motions is using vertical floats attached to the seaplane. The vertical float concept was suggested by Mr. E. H. Handler, Bureau of Naval Weapons, and it appears feasible for incorporation into a future GETOL, VTOL, or STOL flight article.

Under subject contract, the General Dynamics/Convair Hydrodynamics Laboratory modified a 1/20 scale PBM-5 model for testing in both regular and irregular waves with vertical floats. Comparative tests were made without floats in the normal PBM hullborne condition. No attempt was made under this contract to provide for retraction or otherwise stowing the vertical floats.

A motion picture record was taken of selected portions of the tests and should be considered as part of this report. The film clearly shows the dramatic motion reductions obtainable with the vertical float installation in waves of various lengths. Only motion picture data was recorded for the outdoor testing.

1 DESCRIPTION OF TESTS

Testing for the vertical-float system was done using a 1/20 scale model of the PBM-5 seaplane furnished by BuWEPS for the program (see Figure 1). The seaplane hull was properly ballasted to accurately simulate full-scale weight, center-of-gravity position, and moments of inertia.

Model data is as follows:

a. Hull Configuration:

Gross Weight	=	7.00 lb.
C.G. Location	=	30% M.A.C. @ scale C.G. height
I_P	=	0.145 SL sq. ft.
I_R	=	0.186 SL sq. ft.

b. Vertical Float Configuration:

Gross Weight	=	7.6 lb.
C.G. (Hor.)	=	30% M.A.C.
C.G. (Vert.)	=	1.4 in. below hull configuration value

Each float supports 25% of gross weight

Roll waterplane area = 3.69 sq. in. (each float) @ 24.75 in. from $\mathbb{C}_L$

Pitch waterplane area = 6.70 sq. in. (each float) @ 18 in. from C.G.

I_P and I_R was not determined

Damping plate size (each float) 5 in. x 5 in. (square)

Design waterline = 6.0 in. below hull keel

Figure 1 — PBM Vertical Float Model in Waves

Figures 2 and 3 illustrate plots of motions in pitch and roll. System natural periods were:

Without Damping	With Damping
Pitch 4.04 sec./cycle	5.20 sec./cycle
Roll 3.81 sec./cycle	6.20 sec./cycle
Heave 1.10 sec./cycle	4.55 sec./cycle

Metacentric Height (Pitch) = 2.14 in. above C.G.

Metacentric Height (Roll) = 2.50 in. above C.G.

The wave height selected for all of the indoor tests was 3.0 in. At this height, a wide range of wavelengths (3 to 20 ft.) can be generated and reliably reproduced. Since the model is 1/20 scale, the corresponding full-scale wave would be 5 ft. high and from 60 to 400 ft. long. For a Neuman distribution of wave heights, a significant height of 5 ft. lies at the lower limit of sea-state 5. Accordingly, the convenient model wave height selected has appropriate physical significance in that it approximates the wave conditions anticipated during full-scale operations (sea-state 4).

All indoor model tests were conducted with zero wind velocity. It was felt that the effect of a steady wind upon the dynamic response of the model would be small and the additional effort unwarranted for these preliminary tests.

It was found necessary to have considerable metacentric height in order to offset the destabilizing effect of structural flexibility of the relatively flimsy model. The vertical floats were guyed to the hull with fine wire, the damping effect of which was not determined. Position of wires is shown in Figure 4. To maintain model position with respect to the data camera, the same system of restraint was employed for both configurations. It consisted of a low-modulus counterbalance using strings attached to the model and running horizontally over pulleys to small weights hung in the tank. With the forward weight slightly

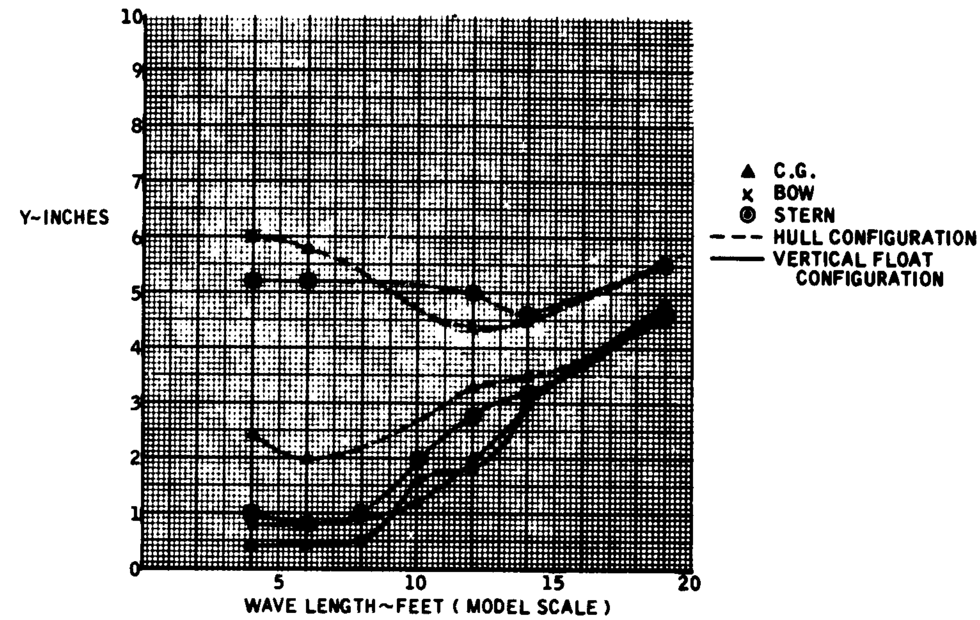


Figure 2. Plot of Motions in Pitch

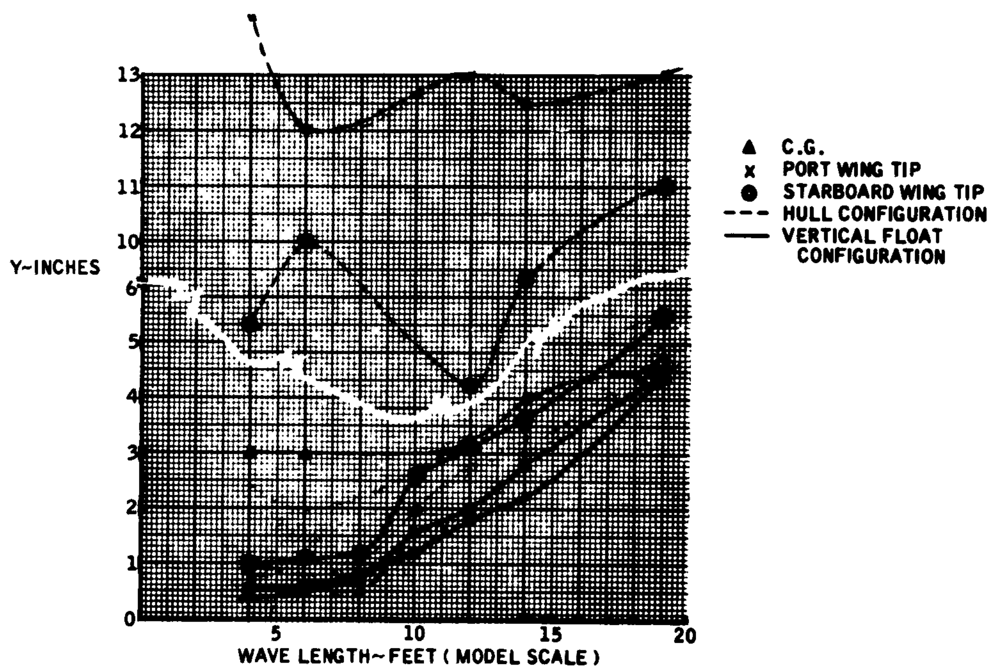


Figure 3. Plot of Motions in Roll

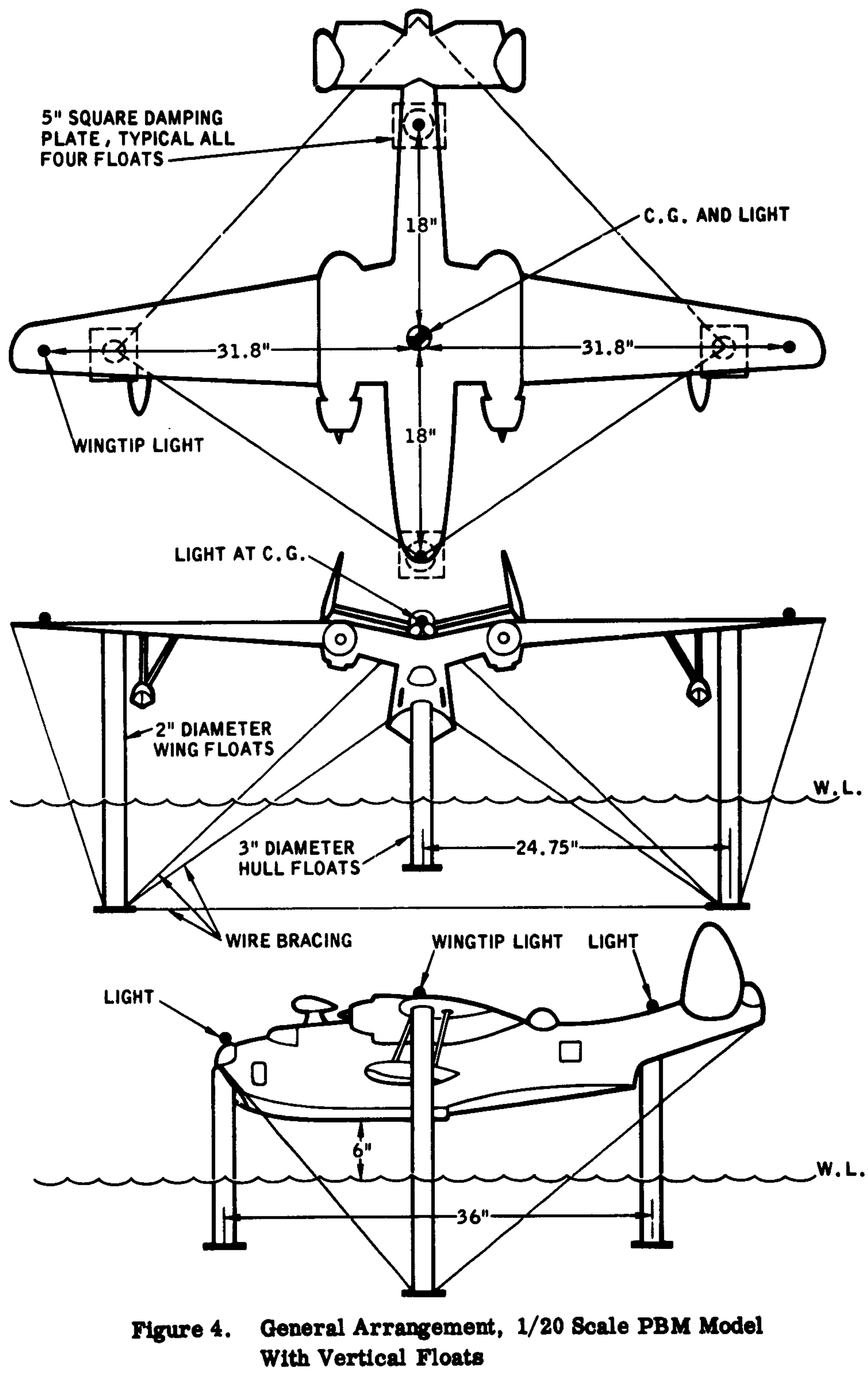


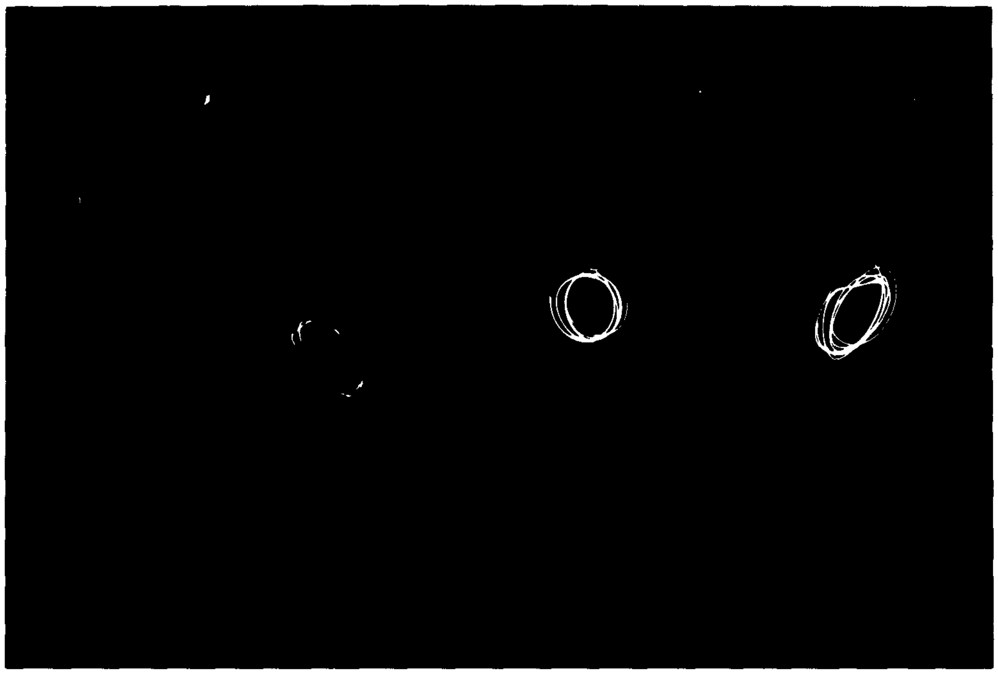
Figure 4. General Arrangement, 1/20 Scale PBM Model With Vertical Floats

heavier, the model traveled forward until that weight rested on the bottom. Wave action caused the model to drift slowly in the direction of wave motion. Small lights on the model were photographed with the data camera. The lights appeared as circular traces which were subsequently scaled to a calibration grid, yielding the vertical double-amplitude displacements. Figures 5 through 8 show typical sequences of the data photos using this technique. Although data was not taken for the model testing in San Diego bay, this portion was covered by the colored motion picture film which forms a part of this report.

Hull Configuration

Vertical Float Configuration

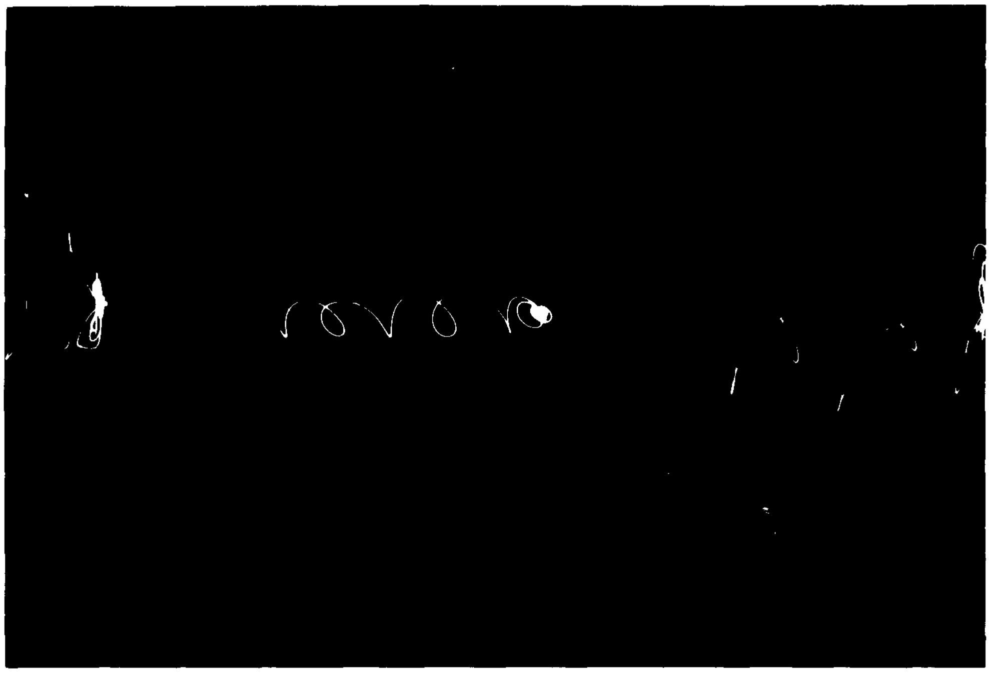
Figure 5. Comparative Motions in Pitch - 4-ft. Wavelengths



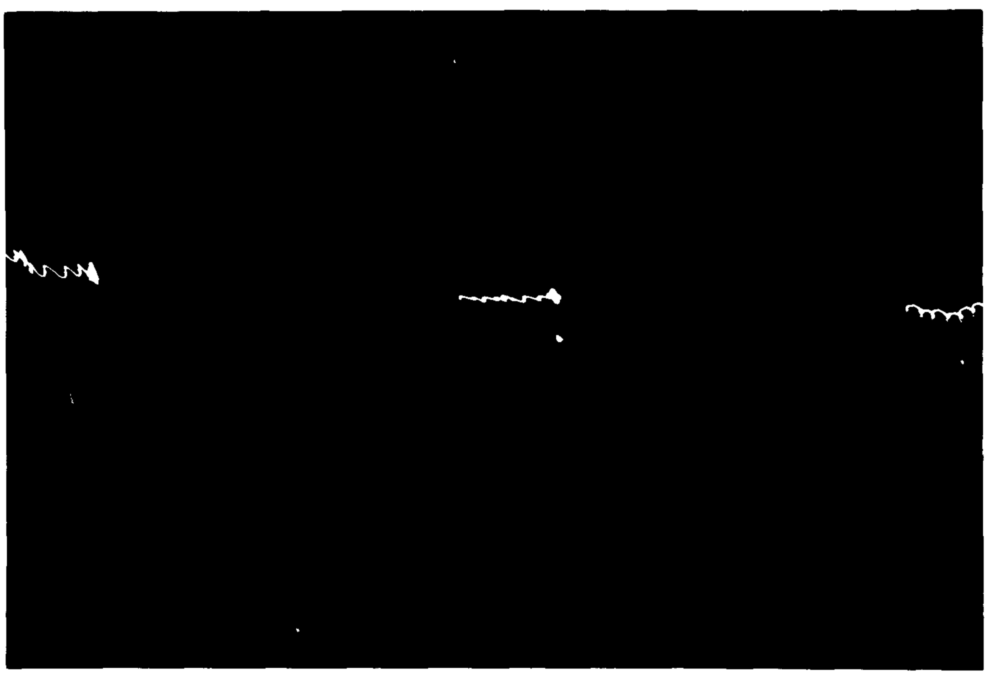
Hull Configuration

Vertical Float Configuration

Figure 6. Comparative Motions in Pitch - 19-ft. Wavelengths

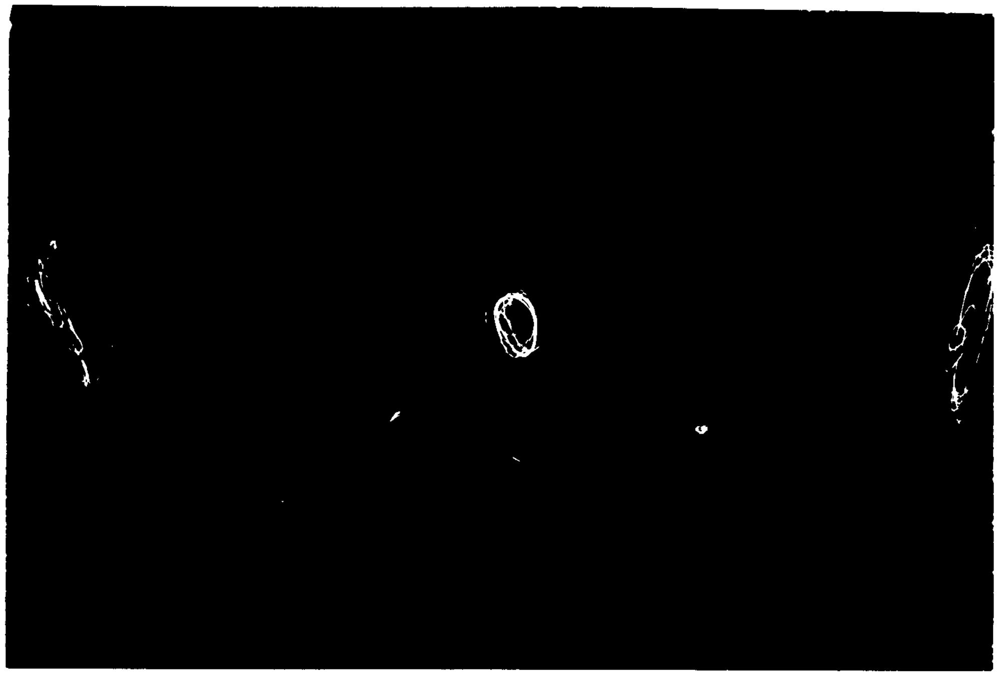


Hull Configuration

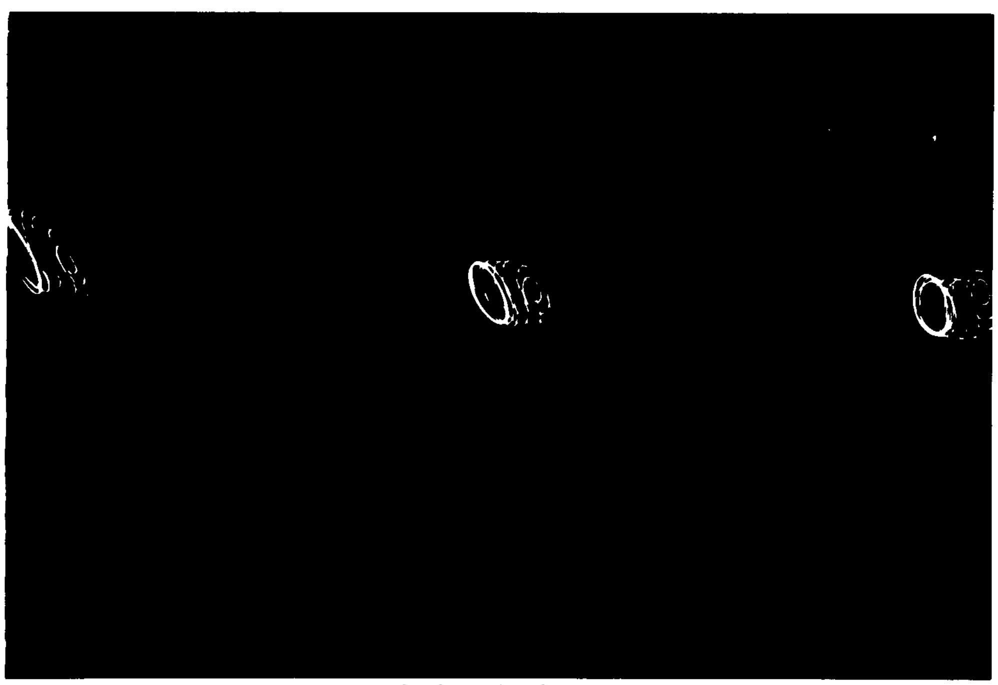


Vertical Float Configuration

Figure 7. Comparative Motions in Roll - 4-ft. Wavelengths



Hull Configuration



Vertical Float Configuration

Figure 8. Comparative Motions in Roll - 19-ft. Wavelengths

2 TECHNICAL DISCUSSION

During the entire testing phase, the major problems encountered were associated with the structural flexibility of the PBM model. Accordingly, it was necessary to incorporate an appropriate amount of metacentric height, GM, to offset the destabilizing effect of the model flexibility. In view of the large motion reduction already achieved, it appears questionable whether a smaller GM will yield significantly smaller motions. Should a tethered, vertical-float system be analyzed for the effect of wind loads, a large GM may be required for static stability. Therefore, the concept of closely approaching neutral stability in an operational system is questionable.

The actual design of the vertical-float system readily lent itself to rational calculation. The test results themselves emphasize the effectiveness of a properly designed vertical-float system for producing a stable platform.

In any system, optimum damping is desirable. However, even heavy overdamping of the vertical float system produced excellent results. The tests showed that adequate damping in the heave mode is definitely required since the heaving oscillations of the vertical float configuration were extremely large without the damping plates. Pitching and rolling motions of the vertical-float model were almost nonexistent when compared to the violent thrashing of the conventional hull in 3-in. waves.

Based on the results of the 1/20 scale model testing, the following recommendations are made for the design and installation of vertical floats for the

full scale PBM-5 seaplane:

Estimated PBM-5 gross weight in the test configuration	45,689 lb.
Fuselage vertical float diameter	58 in. ID
Fuselage vertical float length below water level	117 in.
Wing vertical float diameter	44 in. ID
Wing vertical float length below water level	204 in.
Distance from center-line of airplane to wing float	400 in.
Distance from center of gravity to fuselage floats	299 in.

These locations for the vertical floats are partially dictated by the availability of the PBM-5 structure capable of carrying the float loads.

The bottom damping plates will be circular 108-in. diameter. typical for all floats.

3 CONCLUSIONS

The model tests indicated that a vertical float system can be designed for seaplanes such that only minor pitching and rolling oscillations will result in sea-state 4.

With the employment of an optimum vertical float system, seaplane heaving will be of small magnitude in sea-state 4.

Seaplanes with vertical floats have low drift rates when compared to conventional hulls.

The over-all results of the model tests are satisfactory enough to warrant immediate full-scale investigation of this principle, including studies to determine its effectiveness in ASW.

The most obvious application of a full-scale, vertical-float system is to a a long-range VTOL or GETOL type vehicle. The ability, not only to land, but to survive and operate on the surface of rough oceans has obvious advantages in ASW or air-sea rescue operations. The vertical-float system appears to be a promising solution to the on-the-water survivability of future seaplanes.

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